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Method of manufacturing a composite material

Background art

The invention relates to a method of manufacture of a composite material according to the introductory part of claim 1, a composite product according to the introductory part of claim 9 and an apparatus for performing the method according to the introductory part of claim 11.

Composite products comprising a reinforcing woven material and a PTFE foil are used for many different industrial purposes. Within the chemical industry, this kind of material is for example used for vessels, compensators, containers, conveyor belts and chemical barriers in general that must be able to resist strong chemical and thermal impacts. This is likewise the case within power plants, the food industry and many other applications where reliable and strong mechanical and/or chemical properties are also important.

In a composite material of the above kind the interaction between materials in the composite will create the properties that makes the composite material suitable for a given application. Typically, the woven material will improve the mechanical properties during a thermal impact whilst the applied PTFE foil or foils will constitute barrier properties that can be maintained even under high temperatures.

However, it has proven difficult to obtain a proper "balance" between the individual components of the composite material during its manufacture. This is

because a composite product typically shrinks relatively much during the manufacturing, so that the final end composite product displays significantly different dimensions than those of the original laminated product. This is in particular a problem in relation to the manufacture of composite products with pre-determined end dimensions, just as there is a tendency for the composite product to bend or wrinkle particularly in the edge regions.

Apart from the problem in itself that the composite shrinks or in other ways are disfigured, it is also a problem that it can be difficult to predict which dimensions the end product actually obtains. This results often in that the composite product, where it is possible, must be machined further after the lamination. This further treatment such as machining results in material waste just as it most often is not possible to carry out the further treatment of a product in an automated manner.

Furthermore, it must be mentioned that the material waste as a result of the shrinkage of the material in itself is so high that it is a significant factor in the final production price. An laminated assembly to composite product of the above kind can shrink with more than 10 %.

A way of improving the manufacturing process is by adding to the woven material an extra layer of coating on the opposite side of the provided lamination of PTFE foils.

This solution however makes the manufacturing process more expensive in itself, results in an increased use of

material, and finally results in that the finished composite materials are increased in thickness and weight.

Disclosure for the invention

By, as disclosed in claim 1, to cool the composite material subsequently to a fully or partly fixed state, a composite material with an improved form stability, reduced shrinkage and an enhanced E-module is obtained.

By reducing the shrinkage for the PTFE of the composite, a better form stability for the product as a whole is hereby obtained, since the woven material typically is very sensitive to shrinkage by lamination with a foil.

The main purpose, that is to obtain an improved form stability, is thus a very important factor in connection to a precision produce of composite products, conduit linings, compensators, conveyor belts, tank liners, containers or similar applications, where a poor form stability results in that the finished product shrinks with a relative large and not fully determined percentage.

This is also the case where the composite materials, in for instance chemical plants, is combined with form stabile components with known dimensions, since it can be tremendously difficult to predict the dimensions of the finished composite product.

A fixation of the composite could as an example be carried out by expanding the composite in a frame, and then carry out a cooling by the use of a gas or a liquid.

By the invention it is preferred to let the cooling take place as quickly as possible after the heating.

By a reinforcing woven material is understood for instance glass fibre fabric, PTFE fabric, PTFE coated glass fibre fabric or other materials. However it is preferred in many applications to use glass fibre fabric. By a ePTFE foil is meant an expanded PTFE foil.

According to the invention, by fixation in full or partly of the composite during the cooling, it is further possible to regulate or control the shrinkage of the finished product. This is of major importance in relation to products where high dimensional requirements are requested of the end product. A part of the cooling process can for instance be carried out in a fixed state, whilst another part of the cooling process can be carried out in a non-fixed state.

It is understood that the invention can be carried out as a sub-process of a total process, since it is possible to manufacture a composite material with one added layer of foil and fabric at the time, so that a multi-layered composite material can be manufactured by laminating one layer to the composite at the time.

Besides there is achieved the significant advantage that the finished composite material according to the invention in itself exhibits a significantly reduced shrinkage of the end product relative to the added foils and fabrics, which means that the utilisation degree can be enhanced by at least 10 %.

Moreover, a major trimming of the edge regions can be avoided, whereby the waste of material in this relation is reduced.

By, as described in claim 2, to let the cooling be carried out over a period of time of approximately 0.1 to 240 seconds from a temperature of 300 to 420 °C to a temperature of about 50 °C, an advantageous and practical embodiment of the invention is achieved.

It is preferred for many of the used material thickness that the time period is approximately 20 to 120 seconds from a temperature of 380 to 400 °C to a temperature of about 50 °C.

It is understood that the time and cooling process is very dependent on the thickness and the properties of the individual components.

It should be emphasised that the cooling can be done rather quickly, whereby the combined cooling and fixation is vary attractive in connection with automatic and continuous manufacturing processes.

It is further understood that improved results can be achieved by performing a cooling according to the invention over a part of a temperature interval, just as it is understood that the best result, however, first will be achieved when cooling over the whole temperature interval, i.e. from a given high temperature to a wanted end temperature.

By, as described in claim 3, to let the composite material be subject to a tension during the cooling, an advantageous embodiment of the invention is achieved.

By, as described in claim 4, that the composite material undergoes a combined cooling and pressure operation by means for pressure application, an advantageous embodiment of the invention is achieved, since the means for pressure supply fixates the composite material during the cooling, which results in a solid improvement of the form stability. Specifically, a particularly high E-module can be achieved for the final composite product, just as a good form stability is achievable. This means for instance that the shrinkage of a composite material manufactured according to the invention will be significantly reduced. By certain types of products the shrinkage can be reduced with a factor 10-15 and the E-module can be enhanced by a factor 5.

The achieved fixation by means for pressure supply also means that the composite can be cooled during a very high pressure, as the composite hereby is fixated in a controlled manner during the entire cooling. This high cooling pressure results firstly in that the form of the composite is maintained during the cooling in its final shape, and secondly that the cooling takes place much more quickly across the surface. An improved contact between the means for pressure supply and the composite thus leads to an improved mutual heat transport, whereby the cooling of the composite can be accelerated.

By, as described in claim 5, that the means for pressure supply is provided with cooling means, a particularly

advantageous embodiment of the invention is achieved, since it has been discovered that this combined cooling and pressure application results in an optimal result with respect to the produced composite materials. Firstly, a product with improved shrinkage properties is achieved, secondly, the product can be produced with a relative uncomplicated control.

As mentioned above, an improved contact between the means for pressure supply and the composite thus results in an improved mutual heat transfer whereby the cooling of the composite can be accelerated.

By, as described in claim 6, that the pressure supply is provided continuously by means for pressure supply comprising at least one roller, there is established a commercially advantageous possibility of providing a continuous production of a form stabile composite material and/or a high E-module.

The production can further be carried out in a relative high speed.

By, as described in claim 7, that the pressure supply is provided intermittently by means for pressure supply comprising a pressure surface, there is achieved a particular advantageous embodiment of the invention, as the pressure supply applied by a pressure plate can be completely controlled in the sense that any supplementary tension in the foils or the surface direction of the composite in many applications can be totally avoided.

The pressure supply can be provided by controlling only one parameter, i.e. the pressure provided by the means for pressure supply. By using this pressure surface it is avoided that the diffusion properties are influenced uncontrollably by simultaneous tension in the foils or the composite.

As a pressure surface is in this connection for instance understood a plate, just as a pressure surface can be in the shape of a form.

It is preferred according to the invention to use a relative high surface pressure, since the fixation thereby becomes better during the cooling. As an example a pressure of 0.1 - 20 N/mm^2 can be used.

A high surface pressure on the composite material during the cooling will result in improved material properties both with respect to the form stability and performance, just as shrinkage in the flow direction in the continuous process is reduced, as the composite due to the use of a pressure plate also is held in its longitudinal direction during the cooling.

By, as described in claim 8, that the composite material is cooled under a substantively uniform pressure over the surface by a cooling surface, a possibility is achieved to obtain a composite material having uniform shrinkage properties over the entire surface.

By, as described in claim 9, that the product comprises at least one foil layer of PTFE or ePTFE foil and at least one layer of reinforcing woven material, a product

is achieved possessing a high E-module and other advantageous material properties.

A further advantage by a composite product of the above mentioned kind is that the edge properties become improved considerably, as a reduced shrinkage of in particular materials that consist of for instance a layer of PTFE foil laminated without the use of the teaching according to the invention would have a tendency to curl or "wrinkle" in the edges of the composite product. This disadvantage is partly equalised by the improvement of the shrinkage properties, that is less shrinkage, just as the fixation of the composite during the cooling improves the resulting form stability overall in the product - and thereby also in the edge sections.

By, as described in claim 10, that the reinforcing woven material consists at least partly of glass fibre fabric or PTFE coated glass fibre fabric, a particular advantageous embodiment of the invention is achieved. The invention has proven itself particular advantageous with respect to the relative high sensibility compared with a laminated PTFE foil. It has proven possible to produce composite products, e.g. discrete components, endless webs of the composite etc., without that the dimensions of the final products divert substantively from the original form of the composite in its non-final state.

Under all circumstances it is possible according to the invention to obtain a larger degree of predictability with respect to the shrinkage.

The drawings

In the following, the invention is further described under reference to the drawings, where

fig. 1 shows a preferred embodiment of the invention, and where

fig. 2 shows a further embodiment of the invention.

Preferred embodiment

In figure 1 a schematic view is shown of a preferred automated embodiment according to the invention.

In the viewed embodiment, the shown apparatus is fed by endless webs of PTFE foil 1 and PTFE coated glass fibre fabric 2 from a roll of PTFE foil 3 and a roll of PTFE coated glass fibre fabric 4. The finished composite 9 is wound up on a roll 10.

According to the viewed embodiment the webs 1 and 2 perform a relative movement relative to the apparatus and the rollers 3, 4 and 10 are rotated by not shown forwarding means in an intermittent movement in between two co-operating heated pressure surfaces 5 and 6. These pressure surfaces 5, 6 are in the shown embodiment connected to not shown hydraulic pressure- and movement means and adapted to perform a relative movement to and from the two webs 1 and 2.

The above stepwise movement in the longitudinal direction essentially corresponds to the pressure surfaces 5, 6.

When the stepwise movement has fed two new partial lengths of foil 1 and glass fabric 2 in between the pressure surfaces 5, 6, the pressure plates 5, 6 will move against the webs and perform a combined pressure and heat treatment so that the foil 1 and the glass fabric is joined together in a lamination.

According to the viewed embodiment, the foil and the glass fabric is heated to a temperature of approx. 380°C - 400°C under a pressure of 0.1-20 N/mm^2.

When the lamination is completed the pressure surfaces 5, 6 are moved away from each other and the now laminated composite is moved in an intermittent movement in between two co-operating cooling means.

The cooling means will over a time period of 20 - 120 seconds cool the composite to a temperature of about 50°C and applying a pressure of 0.1 - 20 N/mm^2.

When the lamination of the partial length is completed the pressure surfaces are moved apart and the composite web is rolled up on a roll.

It is understood that the above described process is a continuous process where a cooling of a partial length is carried out simultaneous with the heating of the preceding partial length.

It is moreover understood that the different process parameters can be adjusted and optimised to the properties and thickness of the chosen materials.

It is thus within the scope of the invention to vary the temperature and the time intervals with respect to the applied materials and the wanted result.

It is likewise understood that the composite also could be applied a multiple of lamination and glass fibre fabric layers until the wanted thickness and the wanted material properties are achieved.

In fig. 2 a further embodiment of the invention is shown.

In the shown embodiment the apparatus is fed by endless webs of PTFE foil 1 and a PTFE coated glass fibre fabric 2 from a roll of PTFE foil 3 and a roll of PTFE coated glass fibre fabric 4. The finished composite 9 is wound up on a roll 10.

According to the shown embodiment the webs 1 and 2 perform a relative movement relative to the apparatus and the rollers 3, 4 and 10, that are rotated by means of not shown forwarding means in a continuous movement in between two co-operating heated pressure surfaces in the shape of rollers 15 and 16. These rollers 15, 16 are in the viewed embodiment connected to not shown pressure means.

When the continuous movement has fed the two new partial lengths of the foil 1 and the glass fabric 2 in between the pressure rollers 15, 16, the pressure rollers are moved relative to the webs and apply a combined pressure and heat impact so that the foil 1 and the glass fibre fabric are joint together in a lamination in a continuous movement.

When the relevant part of webs have been moved away of the rollers they are laminated and are forwarded in between two co-operating pressure surfaces 7, 8 that are provided with cooling means.

The cooling means will over a time period of e.g. 0.1 seconds cool the composite to a temperature of about 50°C whilst under pressure.

The composite is finally wound up on the roll 10.

It is understood that many different types of apparatuses can be designed for the performance of the invention.

As an example thereof, it can be mentioned, that the corresponding pressure surface arrangement displayed in dotted lines could be omitted.